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Technology on Reducing Post-harvest Losses and Maintaining Quality of Fruits and Vegetables in India

Sita Ram Jat
Department of Horticulture, Government of Rajasthan, India

Abstract

Fruits and vegetables are highly perishable in nature. A considerable amount of these commodities produced in India is lost due to improper postharvest operations; as a result there is considerable gap between gross production and net availability. Post harvest loss reduction is essential to make available more food from the existing level of production. The losses can be minimized by following simple management practices, such as, sorting and grading, pre-cooling, suitable packaging, proper handling, storage and supply chain management. Therefore, to achieve the target of feeding the growing population as well as meeting the requirements of the processing industry and export trade, only increasing the production and productivity will not be enough. A lot more emphasis needs to be given to post harvest management and maintaining quality of these highly perishable crops.

Introduction

India being a home of wide variety of fruits and vegetables holds a unique position in production among other countries. The diverse agro climatic conditions in the country make it possible to grow almost all varieties of fruits and vegetables. Recent economic growth and changes in dietary patterns have made both the production and consumption of fruit and vegetables increasingly important. The fruit and vegetable sector has a vital role in farm income enhancement, poverty alleviation, food security, and sustainable agriculture. This sector plays a significant role in Indian agriculture. The contribution of horticultural crops towards agricultural output and export earning of total agricultural produce is very high considering the percent area covered by these crops. The horticulture sector contributes around 28% of the GDP from about 13.08 % of the area and 37% of the total exports of agricultural commodities in the country. Although India is a major producer of horticultural crops, many Indians are unable to obtain their daily requirement of fruits and vegetables, a considerable amount of fruits and vegetables produced lost due to improper post harvest operations; as a result there is a considerable gap between the gross production and net availability. Furthermore, only a small fraction of fruits and vegetables is utilized for processing compared to other countries.

India with its current production of around 62.8 million MT, accounts for about 11% of the world's fruit production. The area under fruit crops in India is 5.81 million ha with a production of 62.86 million tons. Among the horticulture crops, at present fruits crops recorded a two folds increase in area and production as compared to 1991-92. India occupies first place in the production of mango, banana, papaya, pomegranate, sapota, aonla and acid lime. About 39% of the world mango and 23% banana are produced in the country. Major fruit producing areas are distributed in subtropical and tropical parts of the country and a limited area has been harnessed in the temperate region. It is a matter of great concern that approximately 25 to 30% of fruits are lost during transit and storage, highest being about 40% in banana followed by mango. As a result the net quantity reaching the consumers is about 90 g of per capita availability daily as against a recommended consumption of 120 g per capita/ day. One of the factors aggravating post harvest losses of fruits which are seasonal and perishable is the utilization of very meager quantities for processing. Less than two percent of total fruits are processed for various products.

India has emerged as the second largest producer of vegetables with a total estimated production of 122.26 million tons from an area of 6.15 million ha with productivity level of 15.82 ton per hectare. In the last one and half decade, country's vegetable production has almost doubled and gross vegetable productivity of the country by one and half times. Presently, India's share is 11% of total world production of vegetables. But less than 2% of the total vegetable production in the country is commercially processed as compared to 70-80% in developed countries. Major contribution to vegetables comes from potato, tomato, brinjal, okra, beans and cucurbits. India is the first in cauliflower production, second in onion production and third in cabbage production in the world. Still, per capita availability of vegetables is 190 grams against the requirement of 280 grams.

Present Status of Post Harvest Technology in India

India has a strong in horticulture production base. However, among other things, the lack of a modern supply chain including cold chains has prevented this strength from being fully leveraged either for exports or for processing. As a result India has a little over 1% share of global fruit and vegetable exports despite having over 10% of the world's production of fruits and vegetables. At the same time, considerable postharvest losses occur in fruits and vegetables, owing to the lack of suitable harvesting equipment, collection centers in major producing areas, suitable packing containers, commercial storage facilities, a cold chain and proper transportation systems. Losses in fruits and vegetables are estimated about 30% due to mismanagement, valued at nearly Rs. 13600 core in fruits and Rs. 14100 core in vegetables annually depending upon the fruit variety and the postharvest handling system. Spoilage of fresh produce is also accelerated by the hot and humid climate of the region.

The small farmers lack resources and are unable to market their produce and implement suitable postharvest handling practices. Therefore, to achieve the target of feeding the growing

population as well as meeting the requirements of the processing industry and export trade, only increasing the production and productivity will not be enough. A lot more emphasis needs to be given to post harvest management and maintaining quality of these highly perishable crops. The only way to cope with the present situation is to give a massive thrust to post harvest loss reduction in order to make available more food from the existing level of production. To achieve the target we shall have to adopt advanced technology in our post-production system of horticultural produce. The detailed analysis of current status of post harvest technology in India is as under:

New Initiatives for Development of the Sector

In past few years, considerable emphasis has been given to the production of horticultural crops in India. There is sharp increase in budgetary allocation in horticulture sector from IV to X plan i.e. 1700 times for research and 5800 times in respect of development programmes. At present the programmes related to horticulture crops form approximately 30 percent of the total outlay of agriculture development of the Department of Agriculture & cooperation. Five new development programmes launched during the X plan namely; Technology Mission for Integrated Horticulture Development in North-East region & Himalayan States, National Horticulture Mission, National Mission on Medicinal Plants, National Bamboo Mission and Micro Irrigation Mission to achieve the transformation of horticulture utilizing the technology. These programmes have been invested Rs. 2400 crore during X plan and continuing during XI plan with budgetary support of Rs. 14134 crore for overall development of Horticulture sector with end to end approach.

The efforts in the investment have been rewarding and the area under horticultural crops has been increasing. The increase in area which was 2.3% and 2.43 %during the VIII and IX plan significantly went up to 6.6% in the X plan. Accordingly, the area under fruits from 3.8 million hectares in 1999 has increased up to 5.81 million hectares in 2008 with an increased production of about 20 million tons. The area under vegetable cultivation also showed a similar increase of 1.85 million ha from 1999 to 2008 with an increased production of 34.67 million tons.

The new schemes are having provision of financial assistance for establishment of post harvest infrastructure to increase marketability of horticulture produce, adding value to produce, increasing profitability and reducing losses. Different post harvest activities like establishment of pack houses, pre-cooling units, mobile pre-cooling units, cold storage units, controlled (CA) storage,/ modified atmosphere (MA) storage, refrigerated vans/ containers/ mobile processing units, ripening chambers, evaporative/ low energy cool chambers, preservation units, onion storage units and zero energy cool chambers etc. being supported under the schemes. To induce investment from private sector in marketing related activities provision of assistance for wholesale markets, rural markets/ apni mandi and retail markets, static mobile vending cart platform with cool chamber etc. have also been made under National Horticulture Mission.

Infrastructure for Technology Development

Horticulture research in India received a boost with the establishment of Indian Institute of Horticulture Research Institute, Bangalore in 4th five year plan (1969 to 74). Rapid expansion of horticulture research infrastructure took place in 7th and 8th plans. Today India has dedicated research infrastructure by way of 10 central Institutes with 27 regional stations, two full fledge State Universities on Horticulture (each in Himachal and Andhra Pradesh), 28 State Agricultural Universities and 15 central/general/deemed to be universities with Horticulture discipline.

Postharvest research is currently conducted mainly by the CFTRI, Mysore, CIPHET, Ludhiana, RRL, Jammu and BARC, Mumbai, CSIR laboratory, Palampur and the DFRL, Mysore. Relatively little emphasis was given to research and postharvest technology in the ICAR system until the late seventies. An All India Coordinated Research Project on Postharvest Technology (AICRP) of horticultural crops was started by the ICAR in August 1978 and four centers in the country (IARI, New Delhi; CMRS, Lucknow; IIHR, Banglore and YSPUHF, Solan). During the 6th plan the AICRP (PHT) was continued by the ICAR and was strengthened by adding four new centers, i.e., TNAU, Periyakalam, KKV, Dapoli, HAU, Hisar and ICAR-RC, Shillong during 7th and 8th plans, four more centers were added, i.e., BCKVV, Kalyani; MPKVV, Rahuri and RAU, Pusa, Bihar, bringing the total to 11 centers under the project.

Packing Stations

Pack houses have sorting, washing, grading, packaging and labeling facilities in addition to pre-cooling. In most of the growing areas, there is lack of the concept of establishing packing stations in India. Fruits and vegetables are generally packed in the field without any pretreatment. In absence of packing station concept, large volumes of the inedible parts of fruits and vegetables are transported to the markets from the field. This increase the cost of transportation and inedible parts ultimately cause sanitation problems.

Recently, several modern pack houses have been established with washing/ cleaning, sorting, grading, waxing, and packaging facilities for fruits and vegetables in the country. National Horticulture Mission, National Horticulture Board and APEDA supported pack house activities by providing financial assistance for establishing these facilities for fruits and vegetables. In modern pack houses most of these operations are done automatically under a cooled house. Belt conveyor conveys the materials form reception to a jet washer. Jet washer removes the dirt and cleans the surface under forced jet of water. After this the produce is graded into three to four grades based on size by power operated size grader. In some cases surface of fruits/ vegetables waxed with edible waxes to have good appearances and enhances shelf life.

Primary Processing

The minimal processing of fruits and vegetables is an area which offers considerable potential for development of the fruit and vegetable sector. Consumers in metro cities are increasingly

demanding ready to eat fruits and vegetables, with a fresh like quality containing only natural ingredients. This has been mainly due to changing life styles. These changing trends have led to increased demand for fresh cut or ready to eat fruits and vegetables. In addition to convenience, consumers perceive fresh-cut produce to be good value of its freshness, cent percent edible food of high quality nutrition.

Today, minimally processing of vegetables such as cauliflower, peas, leafy vegetables, etc has started at some packing stations immediately after harvesting, through the removal of inedible parts and being marketed in metro city markets in unit packs. Consumer friendly products like frozen green peas, ready to use salad mixes, vegetable sprouts, ready-to-cook fresh cut vegetables are major primary processed retail items. Minimally processed produce, however, deteriorates at a much faster rate than does intact fruits and vegetables. Stringent quality management systems such as Good Manufacturing Practices (GMP) and Hazard Analysis and Critical Control Point (HACCP) as well as proper packaging and temperature management are, therefore, required to assure its safety and freshness.

Packaging and Transportation

Packaging is an integral element in the marketing of fresh horticultural produce and it is link between the producer and consumer. It requires at both the stages i.e. from field to market and processor to consumer. From field to market traditional forms of packaging such as bamboo baskets, wooden boxes and gunny sacks are still widely used but plastic crates are gaining more popularity as a packaging material for transport of fruits and vegetables. Considerable work has been done by different agencies in introducing alternative types of packaging. The ventilated CFB box which contains ventilated partitions is found ideal for the packaging and transportation of fruits, owing to the comparably minimal level of bruising observed in these boxes.

Packaging provides handling facilities for loading, transport & storage for both the processor and consumer. Modern technology and changes in consumer demand for convenience and packaged foods, have given both for the development of new packaging material, packaging techniques, machinery, graphics, computer design etc. There is an increasing demand for the new specific and innovative packaging techniques for processed foods. India is a fast emerging market for canned fruits and vegetables. Potatoes, cauliflower, tomato are canned in dry either in natural form or curried type using spices.

Cold Storage

Exposure to the high temperature is the biggest factor in the post harvest losses of fruits and vegetables. The ideal condition for storage of fresh fruits and vegetables is the lowest temperature which does not cause chilling injury. This can be maintained by different type of cooling systems. Cold storages have existed in India from decades for storing perishables. India has more than 5000 cold stores with about 22 million metric tons capacity out which 80% are almost dedicated for

potatoes only and about 17% fall under multi commodity category. Surprisingly only 2-3% of its capacity is utilized for storage of other fruits and vegetables. Most of these units do not have facilities to store a wide range of products across varied temperature ranges. Mainly cold stores are designed for storage of potatoes and in similar conditions fruits and vegetables are stored. In addition to this, different types of fruits and vegetables, which are not compatible to each other, are stored together and causes post harvest losses in different form even in the cold store. The technology in use for cold storage has also largely based on the principle of evaporative cooling with the use of diffusers and bunker coils. The last few years have seen replacement of ammonia with Freon.

The major constraints in the development of cold storage industry in India are high capital cost, high electricity tariffs causing increased operational cost, non-adoption of energy efficient technology and non-professional management. Uninterrupted power supply is essential for cold storage facility which is not always available readily. If refrigeration plant is failed even for a small period and temperature of cold stores increased, induce thermal shock to the produce and causes accelerated loss during storage. Cooling operation is generally for quality; however temperature control is also useful to inhibit the growth of pathogenic bacteria. Therefore, stakeholders at both the ends of value chain farmers and consumers must be aware about the benefits of it.

Cold storage activities in India are limited mostly to tuber crops, onion and Cole crops. Spices like chillies and tamarind are stored largely in cold storages. Apple has been chosen as one to build infrastructure around it as it lends itself to longer duration storage of 8 to 10 months when stored under controlled climatic conditions which is limited to a few weeks under ambient storage conditions. Banana and Mango constitute over 50 percent of the total fruits produced in the country. Litchi, grapes, pomegranate, potato, onion, Chillies are another ideally suited crops for cold chain.

Control Atmosphere/Modified Atmosphere Storage

Modified atmosphere (MA) essentially means any deviation from the normal atmospheric gas composition. If this deviation is strictly controlled with certain specific gaseous concentrations of N_2, CO_2 and O_2 then it is termed as "Controlled Atmosphere" (CA). Usually modification of atmospheres during storage of fruits and vegetables involve reduction in oxygen (O_2) and/or elevation of carbon dioxide (CO_2) concentrations. The use of CA/MA should be considered as a supplementary practice to proper temperature and relative humidity management.

The beneficial effects of CA/MA treatments are retardation of ripening, senescence and physiological changes. In addition it helps in reducing the physiological disorders, e.g. chilling injury of various commodities. Modified atmosphere can have a useful tool for control of certain insects. However, there are certain limitations such as irregular ripening, development of off

flavors and stimulation of sprouting etc. if not properly carried out. The design and construction of controlled atmosphere stores require precision control of the system. The controlled atmosphere store has to be relatively gas tight, and fitted with reliable refrigeration system with a means of measuring and controlling the concentrations of both carbon dioxide and oxygen. Now establishment of CA/MA storages have been started in India after having provision of financial assistance under National Horticulture Mission and National Horticulture Board schemes.

Cold/Cool Chain

While India's strength in the horticultural sector has led to a large production base of fruits and vegetables, the enormous amount of wastages (estimated to the extent of 30%) due to inefficient supply chain has prevented the farmers and processors from reaping the benefits. Eliminating field heat immediately after harvest is very important for extending the shelf life and quality of fresh fruits and vegetables. For this, maintenance of cold chain from grower to the consumer is of crucial relevance for maintaining quality of the product. Cold chain refers to a complete set of supply chain involving the production, storage and distribution of perishable products that require temperature control in order to keep the products characteristics, freshness and nutritive values retained for longer duration. This requires control over various factors such as fluctuations in temperature and humidity and impact from incorrect handling across the supply chain.

The cold chain industry in India consists of a dozen large players such as snowman, Frick India, Voltas Ltd, Blue Star etc. that provide services ranging from refrigeration equipments and storage services to integrated logistics. The services being presently provided rarely cover the entire country leading to breakage in cold chain and consequent produce wastages. Cold chain activities in India are fragmented and mostly confined to retail markets and cold storages. The key issues in the agri-logistics related to the development of the cold chain industry are of non-standard pricing, lack of scientific handling of produce and consequent high prices and limited choices for the consumers. The cold chain operators also do not have knowledge about what treatment and handling to accord to which produce and what sort of cold chain configuration is required for which produce. In addition to the above factors, the perishable nature of the commodity class and the fact that the requirement for cold chain varies across each commodity even within the same class makes the task very complicated.

Despite fairly widespread awareness on the need for a strong cold chain network, adoption in India is continues to be low. Although, the recent development of direct retailing in domestic segment has demonstrated the success and utility of captive end-to-end cold chain in India including that of refer transportation. Desai fruits and vegetables in Gujarat, Namdhari fresh in Karnataka, Adani Agrifresh in Himachal Pradesh are some of the few models in private sector in direct retailing with established cold chain to ensure quality of produce. The cold chain not only

helps in enhancing the shelf life but more importantly the ripening chambers help overcome the health issues associated with common ripening systems using carbide. India's rapid economic growth and ongoing consumer boom have contributed greatly to the growth of retail sector The maintenance of low temperatures at different stages of handling by maintaining cold chain helps in reducing losses and retaining the quality of fruits and vegetables...

The requirements for cold chain extend right across the product value chain and can be very complicated depending upon the nature of the produce and the ultimate customer preference. The possible routes of fruits and vegetables in the country may be as under:

I. Harvest- Primary Market Transport- Secondary Market Transport- Processor- Consumer
II. Harvest- Pre-cooling- Packaging- Reefer Transport- Perishable Center Handover- Doc Unloading- Dispatch- Tarmac- Aircraft

Processing

Presently, less than 2% of fruits and vegetables are processed in India. The prominent items processed in fruit and vegetable processing sector are fruit pulps and juices, fruit based ready to serve beverages, canned fruits, and vegetables, jams, squashes, preserve, ketchups, sauces, pickles, chutneys and dehydrated vegetables. The industry has also taken up the processing of frozen pulp and vegetables, freeze-dried fruits and vegetables, fruit juice concentrates, preserved garlic, ginger and onion pastes etc. Development of new products like juice punches, banana chips and fingers, mango nectar and fruit kernel essential oil from citrus, fruit wines, dehydrated products from grapes, pomegranate, mango and coconut etc. are getting popularity day by day.

The number of processing units based on fruits and vegetables and their installed capacity are increasing at a compound growth rate (CGR) of 3.68 percent and 10.04 percent per annum respectively. However, the actual capacity utilization is about 47 percent. Among the components of processed fruit and vegetable products basket, dried and preserved vegetables accounts for the highest at 60 % followed by mango pulp (15%), pickles and chutney (11%) and other processed fruit and vegetables (13%).

The fruit and vegetable processing industry has been faced with the problems of quality raw material, capacity utilization, transfer of technology being difficult due to majority of the units being in cottage and home scale sector. The recent innovations, if properly utilized, would help overcome the problems of marketing.

Marketing

Due to presence of too many intermediaries and concentration of trade in few hands resulting in exploitation of the growers – sellers, the producer's share in consumer rupee is low. However, in view of the increased production of fruits and vegetables and also to sustain the interest of the cultivators and also to motivate them to produce more, it is imperative that they get a reasonably

high price for their produce. It is also essential to identify the best channel of marketing which ensures this.

Pre-harvest contractors (PHC) are found to be predominant in marketing of fruits as about 75% of fruits has been marketed through PHC. Thus, pre-dominance of PHC in fruit marketing is still continuing despite the fact that it is not desirable practice. The studies on vegetables have shown the pre-dominance of commission agents in their marketing and commission charges is one of the major components of marketing costs.

Transformation is taking place in marketing of high value commodities like fruits and vegetables due to globalization and liberalization. Accordingly procurement and distribution system for fruit and vegetables is also witnessing changes in the form of contract farming, growers associations, cooperative marketing and also integration of production and marketing through processing. Of late super markets (Retail supply chain) are entering the fruit and vegetable marketing in a big way.

Quality and Safety

The quality of fruits and vegetables can be defined on the basis of external, internal and hidden attributes. External attributes are size, shape, color, firmness, defects etc. The internal attributes may be aroma, taste etc. Combination of external and internal attributes generally determines the acceptability of fruits and vegetables. Hidden attributes may be wholesomeness, nutritional value (vitamins, minerals, fiber etc,), and safety aspects (natural occurring toxicants, chemicals residues, heavy metals etc.).

Fresh fruits and vegetables are living tissues which are subject to continuous change after harvest. While some of the changes are desirable, most are not desirable from consumer's standpoint. Grade standards identify the degree of quality in a given commodity that provides the basis for its usability and value. Due to globalization of trade, 32 important fruits and vegetables grade standards have been harmonized with international standards viz; Codex, EC etc. and notified. Grade standards of another 7 fruits and vegetables are at various stages of finalization and notification. This provides recommendations for proper packaging and transport of fresh fruits and vegetables in order to maintain produce quality during transportation and marketing.

In response to consumer concerns, many retailers in various countries require growers to have independent third party inspections of farms to ensure that fruits and vegetables are being grown, harvested and packed using Good Agricultural Practices (GAPs), Good Hygienic Practices (GHPs), Good Manufacturing Practices (GMPs) etc. These programmes have developed rapidly over the past decade and many growing packing operations are being inspected by the agencies approved by the retailers. EUREPGAP/ GLOBAL GAP, Hazard Analysis and Critical Control Point (HACCP), British Retail Consortium (BRC), ISO- 22000 standards, etc. are worth mentioning in this regard.

In India, the farmers generally bring fruits and vegetables to the market without grading and packing. There is need to encourage grading, packing and labeling at farmers level to ensure uniformity and traceability. The cold chain needs to be developed to reduce post harvest wastages and ensure quality and safety of fresh fruits and vegetables. GAPs, GHPs, GMPs and other Food Safety Management Systems need to be promoted amongst farmers and other stakeholders in supply chain to ensure safety of fresh fruits and vegetables.

Modern Processing Techniques

Several new R&D innovations have been made in the field of value addition of fruits and vegetables from different organizations. Some of the new technologies replacing conventional processes are as under:

a. High pressure processing

b. Ohmic heating

c. Microwave heat processing

d. Irradiation

e. Extrusion Processing

The future thrust areas may be oriented towards popularizing these new technologies giving safe packaged large amounts of fruits and vegetables.

Conclusion

The perishable fruits and vegetables need very careful handling at every stage starting from pre-harvest to harvest, sorting, grading, packaging, marketing and storage. For preventing the post harvest losses proper storage, cold preservation, packaging and transport methods with Hazard analysis Critical Control Point (HACCP) norms have to be given more thrust. The cold chain system is effective in reducing postharvest losses in fruits and vegetables. For this infrastructure at proper place and proper time is a key element for post harvest management and value addition of fruits and vegetables. Development of cold chain in rural areas presents the biggest challenge due to lack of existing infrastructure, poor financial strength of the farmers. This can, however, be circumvented through the adoption of an integrated cluster approach involving aggregation of villages in the form of clusters. This can be done in an effective manner wherein infrastructural facilities (pre-cooling and pack houses) can be provided in a pooled manner to the farmers as it would enable risk sharing, improved marketing and market power among producers besides going long way in assuring quality control and economies of scale. Pooling refers to the combination of production from many producers under the marketing skills of a specialized staff.

Most of the fruits and vegetables flow to the primary markets from where they change multiple hands before reaching the ultimate consumer. Lack of facilities along the transportation

route increase the wastage and deteriorate the quality. Hence an effective cold chain network at these places is need of the hour. Diversification of the processed product base, including the production of low alcoholic fermented beverages to make use of surplus quantities of fruit, could be one of the several approaches to reduce the postharvest losses in the country. The quality and safety issues of fruit and vegetable products (freedom from microbial toxin & pesticide residues) is also need to be given greater attention in view of its significant implications for human health.

Based on the information given above the following efforts are needed to accelerate the pace of development of post-harvest infrastructure in the country.

1. Intensify the use of proper harvesting tools and gadget.
2. Popularize low cost sorting, grading equipment at farm level.
3. Popularize mobile sorting, grading, waxing and packaging concept on farm.
4. Develop marketing concept for minimally processed foods at production catchment.
5. Develop clusters of modern food factories in production catchment with good market links.
6. Develop facilities for hands on training in modern food factories.
7. Develop novel value added products from ethnic fruits & vegetable for niche market and export as health foods.
8. Encourage the corporate sector to undertake contract farming of crops to keep away multiple intermediaries between grower and processor.
9. Introduce private and corporate entrepreneurs in sharing investment in the establishment of efficient marketing systems.

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